OF BLIND MEN AND AN ELEPHANT: THE SCHISM OF PHYSICS AND PHILOSOPHY AND NON-EMPIRICAL VALIDATION

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Abstract

Great revolutions in the study of nature in the past century have brought forth an onslaught of philosophical complications to the clarity of the classical perspective to which natural science was espoused prior to the twentieth century. The objective, intuitive principles by which we determined the reality of the world were beset by the ontological implications that flowed out of quantum mechanics and relativistic law. Wary of philosophical problems, a great number of the physical sciences lodge themselves in the comfort of empirical dogmatism as its only means of progression. But in light of the success of quantum systems, the ambiguity that buds must be taken into greater consideration. This paper discusses the background, development, objections, and interpretations of quantum mechanics and concurrent ontological premises to argue that such a philosophical tenet is inherent to nature, and, as such, is capable of producing results and predictions consistent with its physical and mathematical counterparts. To do so, the properties of measurement and the premises of causality are treated in terms of their physical terminology and foundations. The frameworks of Carroll, Everett, Heisenberg, Popper, and others analyze established interpretations and abstractions of quantum mechanics; its ties to the metaphysical and ontological descriptions of an existing entity are explored by means of the contrived spacetime allegory, which in principle determines the parameters that bound real systems. It is evident that ontological accounts for physical phenomena are not only viable and admissible but are necessary as our ability to describe the universe surpasses our ability to test and quantify these descriptions. These realizations allow us to better understand our world and move beyond empirical data when it is technologically unattainable, enabling us to build on statistical bases and approach the structure of realism through its essence of ambiguity.

Introduction

To analyze the universe is no simple task, particularly when doing so from within, but we are so restricted. We were born to a set of spaciotemporal rules by which we understand ourselves and our surroundings. No object may possess any properties, nor manifest in any capacity, if it is undefined in either time or space. Causation occurs exclusively as a result of the passing relationships bound in lapses of interaction between two objects engendered by their own respective representations in space and time. If space is the physical form of objects, then time is the parameter by which physical forms are allowed to interact. To this extent, at a minimum of both are required to produce the world as we know it, and there is no event, no process, no thing that arises without either. Considering a meaning to being seems futile and endlessly subjective. Neither contentious thought nor empirical data has, or could, arrive at an ultimate conclusion—this is the nature of the metaphysical question. It is without wit to ask for the purpose of life, existence, or reality, for an answer is reserved for a greater power than our own. We may then inquire only of its nature. What is it to be? What is, but cannot be observed? What can be observed? Is anything that may be observed a being within such a set of rules that birthed us at the outset?

Though we have gone millennia with no answer to satisfy, our stubborn inquisition has moved our understanding of the world forward. The experiments and theories we have concocted to pry an answer from the universe have begun to produce results, and physical interpretations of reality finally coincide with proper philosophies. To this end we see that we must detach ourselves from a stubborn co-dependence to empirical data to begin uncoiling this terrible knot we have tasked ourselves to straighten. We must define space and time themselves, see to it that the spaciotemporal properties and tendencies are described to the most relevant extent, and then we may see the reality in which we exist, and accept that we may be cursed to misunderstand it, for the deed of becoming reality may be too great for minds so accustomed to its rules. Nevertheless, we hope that the universe is consistent within itself and that the rules to which we were born and raised are as applicable and constricting to the galaxies that we sublime and as they are to the trifling dust we contempt. But what is this thing we have found? What is this language with which we have learned to speak the ancient dialect of our universe? "Can nature be so absurd as it seemed to us in experiment?" (Heisenberg, 2000, p. 13). At its core, mathematics speaks the voice of reason from the dreaming and alluding philosophies of ancient peoples. Mathematicians qualify their thoughts and attach them to observation, to the reality in which their utterances lay. But this was not enough and soon, to count the process of our own affairs, they fell subject to our predictions of the universe. Our obsession with economic transactions and political calculus lost its dominion to the motion of the cartwheel, the drop of a ball from the greatest height, the erection of spires, pyramids, and colosseums. Eventually, we traced the tendencies of the planets, asteroids, and moons. We discovered and eventually admitted to our ego, that we were not the center of the cosmos. That the bright sun set the greatest influence as the origin of our solar system. That the sun is one among countless other great stars that inhabit the same universe we do. That the bounds of the universe are seemingly endless and that we are seemingly nowhere. We, the simple beings on a spec of dirt in a macrocosm of unimaginable parameters, can predict and use the rules of our reality; we may manipulate the piece of the cosmos that envelops us to better peruse it, to better command it, at least insofar as our young race can comprehend it. This thesis concerns an important facet of progress in theoretical science: the inclusion of non-empirical data to determine the viability of a theory. This, I assert, is a matter of statistical relevance to sound bases in fundamental physics. A corollary preposition of such aim suggests that there exists a distinct overlap between profound physical phenomenology and philosophical analyses, which will be explicitly discussed. Thus, the premise of this paper is to study the implications and properties of non-empirical confirmation with respect to scientific analyses with an emphasis on quantum theory and subject them to intensive examination. In addition to this it will be shown that where rational and scrutinized argument may be formed in accordance to the appropriate physical conditions, it should be considered seriously in the foregoing literature.

A Basic Lexicon

In order to establish a basis for this argument, it is necessary to define its recurring terms.

Empiricism is the belief that knowledge is derived from experience and perception. It requires observation. Its advocacy expresses criticism against the naïve use of unquantifiable arguments by the general notion that any postulate must be testable in order to be considered a legitimate idea in the scientific field. The empiricist attitude and its chief prejudices are and have long been deeply rooted in scientific communities. This is understandable. After all, with no technical or quantifiable data, a description of nature holds no physically obvious evidence and, by extension, no propensity for the prediction of real phenomena. And this is the essence of natural science: prediction. With no predictive potential, any argument regarding natural phenomena without the option to be scrutinized through experiment is not considered empirically wrong, but meaningless. Non-empirical predictions do not comply with the rules of conventional scientific scrutiny. Historically, they have been discarded. In this general scientific climate, theories based on conclusive empirical evidence supplant any argument based on rational iterative evidence. This paper shows that an apathy for non-empirical evidence is no longer compatible with the complexities of the phenomena that are now faced in advanced physics. Interpretations of the mathematical schemes of quantum mechanics are rather philosophical and have been discussed in this manner among physicists of great renown. The ontologies, metaphysics, and general abstractions of quantum theory were debated in its infancy and not for another forty years—through Bell's Inequalities and experiments—could they be empirically determined.

Ontology, quite briefly, is a study or perspective of metaphysics with respect to being. Ontic concerns are those of the *true* reality of entities, which may be disparate from the reality we perceive; a Platonic distinction of "Forms" (Ross, 1951, p. 251). They are of the absolute truth of existence, reality, and becoming. And since it is of metaphysics "to worry about something which cannot, by its nature, be tested" (Griffiths & Schroeter, 2018, p. 4), many modern scientists do not concern themselves with its kind; but as this paper shows, if it is reasonable to assert that following a path to a greater objective truth requires progress of any form, then it must be reasonable that it is toward this metaphysical end that we inevitably dedicate ourselves.

Being is of quite a recursive and ornate definition. Its essence in this paper adopts the qualities of German philosopher Martin Heidegger's expression, *Being-in-the-world*. This is a compound description of being where a phenomenon of "world-space," which encompasses the boundaries of an extant whole. It is *unitary* and cannot be broken into pieces despite its potential for a structure of constitutive items (Heidegger, 2008, pp. 54-56). In other words, a phenomenon, or entity, is *fundamental* in the sense that its composition can be neither created, destroyed, nor transmutated; but it may have different parts—constitutive items. However, the constitutive items that Heidegger describes as components of the phenomenon do not apply to physical fundamental particles, which have no internal structure and are composed of no other particles. Instead, Heideggerian constituents occur physically as the *manifestations* necessary of a phenomenon to be considered real, as we shall see. In further arguments it is shown that only through *manifestations* may *interactions*, as the relationships between bodies or phenomena, occur in "world-space." Another term of Heidegger's, *Dasein*, is the self-defined and self-contained index of the property of Being-in-the-world that this paper simply calls *Being*. "Dasein itself has a 'Being-in-space' of its own; but this in turn is possible only *on the basis of Being-in-the-world in general*" (Heidegger, 2008, p. 56). Hence, what may be considered an extant entity is in fact a metaphysical entity whose fundamental definition and manifestation is based upon the rules and parameters of the world it inhabits—its "world-space."

"Being-in-the-world" is the concept upon which all further arguments are built: a great expanse of modes where a form may propagate. These modes are in turn having something to do with the world, which includes both the surroundings and the system itself. For a fundamental particle, however, the latter is least important as it cannot be affected by its own action and must establish an interaction with another system.

Epistemology is the study of knowledge and its relevance here relies on its capacity to define the upper comprehensible boundary of the universe in the faculties of the human mind.

Throughout this paper the terms *particle* and *system* are used interchangeably as a consequence of the properties of a particle, which may manifest within the particle's own coordinate system—its aforementioned "world-space." Also, this terminology follows the convention of discourse of thermodynamics: its use of the terms *system* and *surroundings* forms a clear partition between the system of matter or energy under study and everything else, respectively. Thus, for every system, a particle; for every particle, a system. In this paper, a particle is a simplification of anything that occupies time and space, not a localized bundle of matter or energy in space. As we shall see, at the smallest of scales, particles behave as waves described by a wave function that if measured collapse to have particle-like properties. For instance, an electron is both and neither a particle and a wave, depending on whether or not it's measured. Quantum mechanically, measurement is a conscious interaction with the wave function, not the particle, because the particle is in fact a wave function prior to measurement. Fundamental particles are complete indivisible units composed of no other type of particle other than their own. For instance, electrons, quarks, and photons are considered zero-dimensional singularities. They behave like waves before they are measured and like particles after. They are affected by a different set of forces than macroscopic objects, including strong and electroweak forces, and have non-zero discrete energies. This more modern description of the world is referred to as quantum mechanics.

An "unobserved" wave function is a collection of the possible states that would result from the measurement of a particle. The square of each coefficient sets the probability density that its corresponding wave state would result from such an observation. In Equation 1, for instance, if the constant α were equal to $\sqrt{2/3}$, there would be a $2/3$ probability that a position measurement of $|\Psi(x,t)\rangle$ would result in the state $|\psi_a(x,t)\rangle$, whose position values at time *t* are known. Such an outcome would "collapse" the wave function to a single state $|\psi_a(x,t)\rangle$.

$$|\Psi(x,t)\rangle = \alpha|\psi_a(x,t)\rangle + \beta|\psi_b(x,t)\rangle + \gamma|\psi_c(x,t)\rangle \quad (1)$$

Setting the outcome of the integration of the probability density $|\Psi(x,t)|^2$ of the wave function everywhere at some time *t* to 1 prescribes a 100% probability that the particle described by the wave function exists *somewhere* in space. This condition is called *normalization* (Equation 2). It allows the wave function to represent a real particle by determining the values of the coefficients.

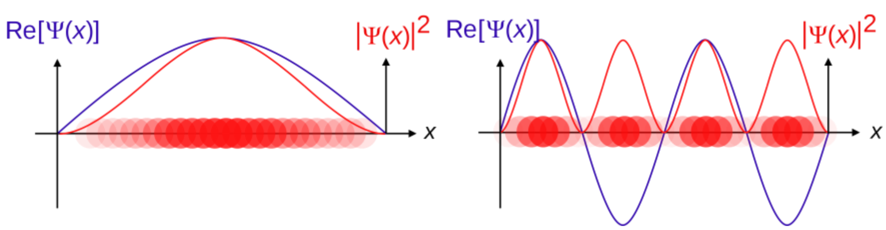
For the Equation 1 coefficients α, β, and γ, $\alpha^2 + \beta^2 + \gamma^2$ equal to 1 (assuming that wave functions ψ_a, ψ_b, and ψ_c are mutually orthonormal). Non-normalizable wavefunction solutions do not represent real particles because they produce an infinite number of possible coefficient values and must, by mathematical necessity, be cast out.

$$\int_{-\infty}^{\infty} |\Psi(x,t)|^2 \, dx = 1 \tag{2}$$

The space-dependent wave function and its probability density are shown more clearly in Figure 1. It shows that the amplitude of each possible wave state corresponds to the phase shift of the wave state. The phase shift of a wave is the extent to which something like a sinusoidal wave is shifted from the coordinate origin at $x = 0$.

Figure 1

Illustration of Wave Function Probability Densities



Note. The real parts of two wave functions are depicted in blue. The probability densities of finding the particles as described by their respective wave function at position *x* are depicted in red. Reprinted from "Wave function" (2013).

This paper will make frequent reference to the so-called classical mechanics of physics. This is a generalization for the study of the motion of macroscopic bodies and the scientific developments that would follow in accordance to the principles of Galileo Galilei and Sir Isaac Newton up to the turn of the 20th century. The transition from classical to modern physics is generally regarded to date back to 1900, when German physicist and mathematician Max Planck presented his now famous derivation for the emission of electromagnetic energy. Planck indicated that the behavior of nearly massless particles could not be described by the laws of Newton or Galileo as packets of continuous energy but consisted instead of quanta of energy traveling through space (Heisenberg, 2000, p. 5). Where classical physics would describe an electron as it would a billiard ball, a particle bound to the forces of gravity, friction, and contact, with non-discrete energies, and with definite positions and moment, modern physics differed. Developments in the early 1900s showed that at the scale of a hydrogen atom, measurable quantities like position and momentum are affected by variations so intense that the uncertainty of a system of non-commuting operators beckons that these operators do not exist simultaneously (Carroll, 2019, p. 49). Operators are formulaic entities that serve to affect a mathematical expression in order to extract some type of information from it, like energy, momentum, position, and others. For this reason, operators are often analogized as, and actually represent, *observables*, physical quantities that can be measured and considered elements of reality (see Elements of Reality). In quantum mechanical systems, operators allow us to determine the simultaneity of quantities—operators that commute can be measured at the same time (at the quantum scale, these quantities do not exist at the same time) and operators that do not, cannot. This property is most famous in the Heisenberg uncertainty principle, which states that position and momentum do not exist simultaneously and so they cannot both be simultaneously measured with infinite precision.

Finally, the properties of measurement. Measurement at any scale is the outcome of an interaction between subject and object, the observer and the observed. In the epistemic line of thought, measurement is the realization of meaning in observation of the form. Then measurement requires a knower who incites interaction as a conscious actor, and the state of the actor may determine the observed state of the measured thing. Quantum mechanically, before the state of some particle is observed, it exists as a superposition of multiple states, each with a certain probability of resulting from measurement, and upon measurement, the wave function describing the sum of states of the particle collapses to one of the states in the initial wave function. A wave function contains the states in which the entity may exist, to which each is assigned an amplitude. Thus, it is not the amplitude of the state that is tied to the measurement, but amplitude squared. Of course, if the superposition of states described one state as more probable than the others, it is this state that is most likely to result from a measurement. It will be shown in later sections that measurement may be considered as the overlap between the manifestation of properties issued from the origin two individual system—the interacting particles.

The Schism of Physics and Philosophy

Early in the nearly three thousand years since the birth of Greek science there was little distinction between philosophy and physics. Before 600 BCE, much of the civilized world based its rationalizations on a basis of divine bearing. The reality of the world was sculpted by the extent to which its people could perceive it through their senses and the meaning of their reality was left to the supreme will of deities (Singer, 1941, p. 28). The movement toward a more rational understanding of nature since then is dated to Greece's Archaic period during which the

“Religion of Science” and its first prophet Thales of Miletus rejected the use of supernatural and religious explanations for natural phenomena (Singer, 1941, p. 35). Three hundred years later, the philosophies of Plato made clear the growing divergence from the notion that humanity is bound to the reality it perceives. In the allegory of the cave, Plato likens men to prisoners bound in the depths of a cave capable only to see the shadows on the wall in front of them. For these men the flat, dark projections cast before them are the one and only reality. They are aware of no other object. Eventually, one of the prisoners escapes the cave and upon witnessing the bright sun, the pale blue sky, beasts of all forms and colors, he is overwhelmed by sorrow for the life lived bound within the cave. For Plato, the real philosopher is the prisoner who stepped out from the darkness and into a greater truth; he possesses the real knowledge. He understands that the natural phenomena we perceive are shades of their ideal “Forms”, truer and greater entities from those to which mankind is familiar (Ross, 1951, p. 251). Then, the path to the Forms lies in intellect. Such a serious allusion to ontic truth blazed a two-thousand-year long trail toward an understanding of a reality beyond our fingertips, which required the scrutiny of our most available perceptions. Of equal influence was the work of Plato’s pupil, Aristotle. While Plato was more concerned with the reality of ideals beyond the physical, Aristotle judged the reality of particular phenomena through the critical analysis of quantifiable and observable objects. His was a science of reason without experimentation. By collecting as much information and opinion as possible, Aristotle cataloged a series of matters including logic, meaning and causation, that placed after his treatise on physics were labeled *meta ta physica,* “After *The Physics”* (MacCulloch, 2009, pp. 119-121): and thus came the birth of the study of the nature of reality.

It is reasonable to think that the work of Aristotle marks an early point in the bifurcation of physics and philosophy. Where physics, the study of nature, the behavior and composition of matter and energy, could be more or less proven by mathematical principles, philosophy of natural law was critically and axiomatically discussed. And where the foundations of mathematics are generally unchanging, the human mind is liable to variation. Over time, development in the fields of empirical trial-and-error and of introspective induction amplified their differences and as of today, philosophy vies for so much as public candidature as a science. Physical sciences became a natural science, while philosophy lost the empirical ground at least in part due to its capacity for overzealous speculation and conjecture (Ross, 1951, p. 205).

If we see that it is true that physics and philosophy are not naturally different, that their common ancestor was logically bound argument and introspection, we must be able to say that they have grown separately. Of physics this speciation must have occurred at the demarcation problem, i.e. what is and what is not a science, with respect to its primary foundation in mathematics, whereas philosophy must have grown as the theme behind any form of wild or serious inquisition into meaning, with its primary foundation in conditional reasoning. The serious inquisitions of the latter are popularly scorned, perhaps because of the public conception of their utility as operationally irrelevant or their association as pretentious circular babble. In any case, it must be true that both physics and philosophy share the grounds of using logic and reason to progress, and if these are the capstones of objective reasoning, where empirical evidence is unavailable we must take non-empirical evidence in the form of critically examined reasoning. Only from there can we proceed. Otherwise we move only in directions that may be backed by empirical evidence and away from those that are not—keeping theory at the pace of technology, not the other way around.

What is the general distinction between a science and a non-science? Generally, sciences are considered verifiable and falsifiable. Then, anything that is unfalsifiable falls under the realm of a non-science. A brusque example tends to take the shape of "Last Thursday-ism", whereby no proof could be produced that falsifies the argument that what is or ever has been was created last Thursday—thoughts and memories included. Physically however, a few nifty trigonometric identities managed to compute the circumference of the Earth, its distance from the Sun, and the period of its revolution thousands of years ago with impressive accuracy and consistent outcomes. Scientific measurements are meant to be reproduced and reiterated with increasingly fine precision. A physical assertion may be made, experimented on, and falsified or verified, and the validity of those approximations and assumptions could be justified or reduced further. Where a line of thought has no operational relevance, it is disregarded in scientific literature. In today's scientific climate, interest in more conjectural branches of physics like string theory has waned. Their decades-long inability to produce any testable predictions has driven their priority to a gross oblivion, though their sterility may lie only in the relatively primitive capacity of the available technology.

If an argument is held to the same standards of scrutiny on the basis upon which it is ground, then we may find that a proclivity to understand our natural phenomena in terms of philosophy and concept, rather than nothing more experimental data, is a noble approach. A wide gap between these may be minimized, and in many ways, justifiably removed altogether where reason and criticism are held to a high standard.

Philosophy and physics are intertwined. Physics is a tool through which we explain reality from the lens of an objective observer appears to have no option but to resort to conjecture at its extremes. To what extent and at what point does the physicist require philosophy to reach a conclusion? Does one require philosophy at all? Is philosophy a fundamental part of truth, or at least a means to reaching truth? Every philosophical perspective is justified and ultimately correct given its set of boundary conditions, its own assumptions and requirements, not perhaps, unlike physics. But any perspective, theory, and claim under any discipline must provide legitimate boundary conditions. That is to say that not any claim can be correct, even if it provides a set of rules.

Elements of Reality

There are number of renditions of physical and rational variables whose objective is to portray as accurate a representation of nature as possible. “Any serious consideration of a physical theory must take into account the distinction between the objective reality, which is independent of any theory, and the physical concepts with which the theory operates” (Einstein, Podolsky, & Rosen, 1935). The conditions whereby the reality of physical phenomena is determined correspond to the elements of reality of a system, physical quantities that can be predicted to some degree of accuracy in an undisturbed system. In this paper, these correspond as the physical counterpart to rational, rather than experimental, implications of real phenomena. Consideration of the notion of allotting general characterizations to real particles on the basis of elements of reality lead to the conclusion that evaluating nature through a non-empirical lens is not without practical purpose.

The debates that arose in the 1930s from the disintegration of classical mechanics of physics extended over many years (Heisenberg, 2000, p. xii). Albert Einstein’s (and a number of his colleagues’) affinity for the classical world view maintained the deterministic notion that the state of nature was impervious to the variations of human experience. That what quantum mechanics interpreted as probabilism was in fact a gap in our knowledge that would otherwise contain a set of hidden variables. In a 1935, Einstein, Boris Podolsky, and Nathan Rosen (EPR) consummated physics' attempt to cling onto this classical perspective with a paper nominally known as the *EPR paradox*. EPR argued that quantum mechanics was not a complete description of reality on the grounds that "elements of the physical reality cannot be determined by *a priori* philosophical considerations, but must be found by and appeal to results of experiments and measurements" (Einstein, Podolsky, & Rosen, 1935). The allusion in the quoted excerpt is to entangled particles, separated but connected particles described by a single wave function. Upon knowing the state of one of these particles, the state of the other is immediately known without having to measure it directly, in principle determining the elements of the physical reality pertaining to the unmeasured particle (see The Discussion of Realism).

EPR's criterion (1935) of reality is stated as follows:

> If, without in any way disturbing a system, we can predict with certainty (i.e., with probability equal to unity) the value of a physical quantity, then there exists an element of physical reality corresponding to this physical quantity.

The physically observable quantities considered in the EPR paper are the operators which obtain a value with certainty for a particle given by a particular state ψ.

$$\hat{A}\psi = a\psi \tag{3}$$

In other words, a variable ("physical quantity" $\hat{A}$) in a world-space consistent with quantum theory, otherwise known as Hilbert Space, corresponds to an element of physical reality capable of determining the state of a particle. Let, for example, E be the total energy of the system ψ, made up the particle's kinetic and potential energies. Since the operator corresponding to the energy of the particle is $\widehat{H}$, known as the Hamiltonian operator, whose function and definition are shown in Equation 4, we obtain

$$\hat{H}\psi \equiv \left[\frac{\hat{p}^2}{2m} + V(x)\right]\psi \equiv \left[\frac{-\hbar^2}{2m}\frac{d^2}{dx^2} + V(x)\right]\psi = E\psi. \tag{4}$$

Thus, in a state ψ, the energy has certainly the value E. This means that the energy of the particle in the state is real.

EPR's distaste for quantum mechanics occurs for physical quantities that do not commute and so the value that one operator extracts from the state precludes the value of the other.

$$\hat{A}\hat{B} \neq \hat{B}\hat{A} \rightarrow \hat{A}\hat{B} - \hat{B}\hat{A} \neq 0. \tag{5}$$

For these values are produced whenever the operators occur with certainty, the non-commutative property of these operators suggest that the knowledge of one element of reality precludes that of the other (Einstein, Podolsky, & Rosen, 1935). The notion that two physical quantities such as these could not be known simultaneously due to the nature of their formulaic interaction meant that they could have no simultaneous reality. A ludicrous thought, according to EPR. We now know that lack of simultaneity of non-commuting observables is true, in large part due to John Bell's work in 1964 (see Discussion of Realism), and so it must follow that quantum observables do not constitute all iterations of elements of reality. Since then more robust propositions for viable elements of reality, like the probability densities of the wave function (Beck, 2018) as shown in Figure 1, have gained traction but they will not be discussed to a greater extent here.

These elements of reality are obviously based on hypothesized, arguably philosophical tenets, and as such they illustrate the ontological implications of modern physics in the most illustrious extents. EPR's work is useful as a prime example of the profound, unresolved correspondence between philosophy and physics, or at least the ways in which the description of physics through rational discussion rather than mathematical formalism can appear as non-empirical confirmation. This shows that intensively examined non-empirical discussions of quantum mechanical systems are relevant, contributive, and certainly existent in esteemed spaces of the scientific body.

The Discussion of Realism

The topic of realism has a deeply contentious history in quantum mechanics. Since its infancy, quantum theory has led physicists far from the simplicity of materialistic perspectives that thrived prior to the twentieth century. The cause of the ensuing decades-long discussion could be better explained no better than in the words of Dr. Werner Heisenberg (2000)

> "Since these views had not only been intrinsically connected with natural science of that period but had also found a systematic analysis in some philosophic systems and had penetrated deeply into the mind even of the common men on the street, it can be well understood that many attempts have been made to criticize the Copenhagen interpretation and to replace it by one more in line with the concepts of classical physics or materialistic philosophy" (p. 83).

The Copenhagen interpretation (1928) was devised in the late 1920s by Niels Bohr as an expression of meaning to quantum mechanics, bestowing upon it the interpretations of probabilistic reality that have been so far mentioned in this paper. Of significant consequence was the interpretation's apparent violation of locality. A postulate of Albert Einstein's 1905 paper on the special theory of relativity, locality is based principally on the prevalence of inertial (at relative rest) frames of reference and the constancy of the speed of light for all frames of reference, regardless of their relative motion. Upon these axioms rests the so-far unchallenged special relativistic law which implies the principle of locality by prescribing the propagation of an event's sphere of influence equal to the propagation of light. In other words, "separated and noninteracting objects are independent" (Popper, 2005, p. 19). Einstein's description of reality beckons a most intuitive quality: an object does not require observation to exist. The advent of quantum mechanics, however, and its use of a wave function as a complete superposition of states challenged the prospect of an objective reality. Quantum mechanics describes reality as a wave function, a set of the number of possible configurations of states, that, according to Bohr's Copenhagen interpretation, collapses into a single state once it is measured (Bohr, 1928). Then a single reality may not be assigned to any object without measuring it. What this implies is that until an object is observed, it does not have a determined value or state, or reality.

In response, Albert Einstein, Boris Podolsky, and Nathan Rosen developed the EPR paradox in 1935, in an attempt to prove that quantum mechanics could not be a complete description of reality. As mentioned in the previous section, the so-called paradox is of entangled particles. Put very briefly, the argument proceeds as follows. Suppose we have two independent particles, *A* and *B*, to which each may be assigned a state within an isolated system. Then they collide, and due to the natural law of conservation of momentum, there must be no change in the momentum within the isolated, composite system; so, the momentum of particle *A* must be equal in magnitude and opposite in direction to that of *B*. If one allows the passage of an arbitrarily long enough time interval before measuring some aspect of either particle, *A* and *B* may be so far apart that they could be of no local consequence to each other and the experimenter may be of no local consequence to the distant particle. Before measurement, the wave functions of *A* and *B* are entangled, that is, describable by one wave function. Then some aspect of one of the particles is measured, say the momentum of *A*, and since momentum is conserved, regardless of separation, we, by extension, know the momentum of *B* without interacting or disturbing *B*, but only through measurement of *A*. Measuring the state of one of these particles tells us the state of the other once the state collapses and A and B are no longer entangled. By the principle of uncertainty, measuring the momentum of A with great precision corrupts the certainty of its position, and vice versa, but without measuring the position or momentum of B, EPR argued that both must have precise values. This piece of EPR's argument is flawed due to the previously discussed complementarity of position and momentum (they, by natural law, do not exist simultaneously, regardless of measurement). The larger argument here is that the state of B could not depend on any measurement done on A; if the state of B is known before its measurement, there must exist real-world variables, or "elements of reality" that affect the outcome of such a measurement. There must be, according to EPR, no effect of our choice of measurement on the state of an unmeasured particle.

Different iterations of the EPR paradox have since been devised. A simple version, due to renowned physicist David Bohm, considers the decay of the neutral subatomic particle, the pi meson (pion), into the negatively charged electron and the positively charged positron (Bohm, 1951):

$$\pi^0 \rightarrow e^- + e^+$$

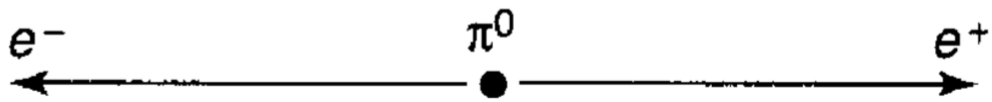
Assuming the pion was at rest, the electron and positron jet off in opposite directions (Figure 2). The pion has zero spin, so because angular momentum is always conserved, the electron and positron must each be in such a spin state to cancel that of the other. The electron may be spinning up or it may be spinning down and, respectively, the positron may be spinning down or up—there's no way to tell which spin state the particles are in without measuring at least one of them. So, we can describe the two-particle system by a single wave function composed of both possible configurations:

$$|\Psi\rangle = \frac{1}{\sqrt{2}}\left(|\uparrow_-\downarrow_+\rangle + |\downarrow_-\uparrow_+\rangle\right) \tag{6}$$

Note. The $\frac{1}{\sqrt{2}}$ factor is a normalization constant, meant to prescribe equal probabilities of outcome to each spin state configuration in the parenthetical argument and assure that the integral of the square of the wave function equals to 1 (see Equation 2).

Figure 2

Illustration of Bohm's Version of the EPR Experiment



Note. A neutral pi meson π^0 decays into an electron e^- and a positron e^+. Reprinted from D. J. Griffiths & D. F. Schroeter (2018).

Suppose we allow the electron and positron move far enough away from each other to render classical (local) interaction between them impossible. Now, say we measure the spin of the electron and get spin up, then we immediately know that anyone who would ever measure the spin of the positron would get spin down. The realist would argue that the electron had spin up from its inception—quantum mechanics just realized it at measurement. An advocate of the Copenhagen interpretation would say that it was measurement itself that created the spin state of the entangled particles, producing the spin down state of the positron by interacting only with the electron. This "spooky action at a distance," as Einstein put it, was the subject of Einstein, Podolsky, and Rosen's (EPR) 1935 paper "Can Quantum-Mechanical Description of Physical

Reality be Considered Complete?", which considered the notion untenable. They concluded the electron-positron pair must have had well-defined spins from their creation; intervening with one particle could not create the state of another particle faster than light could propagate between them—this would violate the principle of locality. They had no doubt that quantum mechanics was correct insofar as the powers of the wave function extended; it just did not provide a complete description of reality. EPR remarked that some other quantities, some "hidden variables," were needed in addition to Ψ to fully characterize the state of the system.

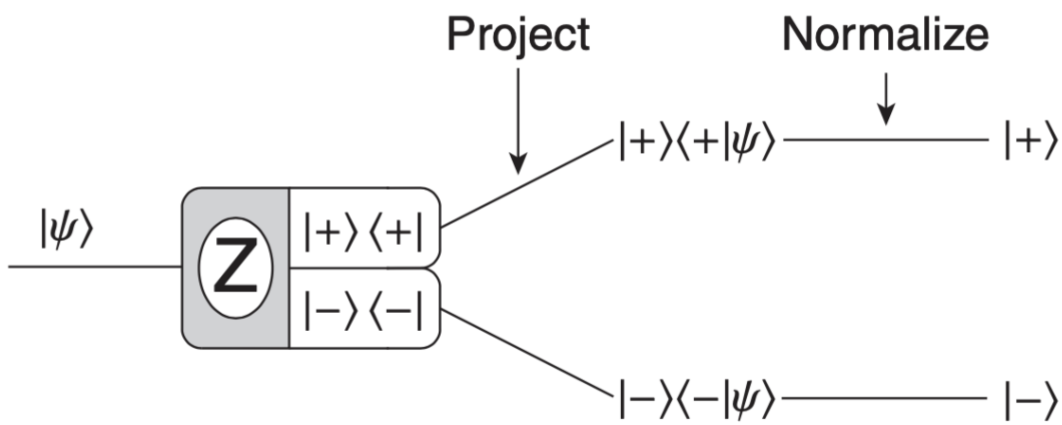
In principle, one of the implications of this phenomenon is that it ascribes measurement the potential to affect the past behavior of a particle. One's choice of measurement dictates the manifestation of wave-or-particle behavior. Measurement is different from learning, so although a measurement can be made, a measurement that goes unnoticed may not be said to have collapsed and have a definite result. Therefore, in entangled pairs, where the state of one component is measured but not seen and the other is measured and seen later affects the seen result of the former component. Knowing the progression of the particle creates the manifestation of the other. Without its wave function having collapsed the unmeasured particle could not be said to be affected by measurement, so its behavior, once known, must have been constant throughout its lifetime. By choosing the form of measurement of particle A, it seems somehow possible to dictate the behavior of particle B from its moment of separation from A. Hence, Einstein's reluctance. These metaphysical attributions of quantum systems are the philosophical manifestations of theory, based on unchallenged mathematical formulism like the entangled spin wave function (Equation 6), and a such may be considered axioms of a metaphysical realism (Heisenberg, 2000).

“It cannot be sufficiently stressed that… nobody before Bell suspected that quantum mechanics itself clashed with locality, and therefore special relativity” (Popper, 2005, p. 20). Locality and realism were not disputed until the experimental results of Bell’s inequalities, which determined there are no hidden variables, no additional, intrinsic elements of reality which determined the state of a particle after collision or interaction. These hidden variables are nascent from a wantonly impulse to interpret natural phenomena in an intuitive, deterministic manner. If this were the case, the probabilistic nature of quantum mechanics that suggests that a phenomenon unobserved really *is* a set of its probable states rather than a single definite state would not be a complete description of nature. In terms of the famous Schrödinger Cat, enclosed in a box with a packet of cyanide, a deterministic reality would describe the poor animal as either dead or alive without having to look inside the box. Probabilistically, the cat is dead *and* alive. This probabilistic interpretation is known as the Copenhagen interpretation, Niels Bohr’s brainchild. It states not that before looking there ought to be a chance that the cat is dead and a chance that it is alive; rather, it states that the cat is simultaneously dead and alive—only after opening the box will you find a rotting carcass, some percentage of the time.

The idea that two particles could instantaneously affect each other without any physical interaction no matter their spatial separation developed into Albert Einstein’s affection “spooky action at a distance.” Entities of causal consequence are “contiguous… nothing can operate at a time or space which is ever so little [removed] from those of its existence” (Hume, 1896, p. 75). Of relations among objects, no cause or effect may occur where objects are not physically adjacent and so distant for their interactions to be limited by the propagation of light—this is the principle of locality. To resolve the matter, Dr. John Stuart Bell proposed a set of inequalities in 1964, which if violated, would suggest a greater viability to the theory that violated it (Bell, 1964). It turns out that locality may be breached, and that two particles may have a causal consequence despite their distance, and so they may be said to be *entangled*. These results then beget that the exhibition of a property must be measured in order to assert its existence. Until then, the state of a particle must be in a superposition of states, a sum of all the possible states in which the particle could exist, whose probability of occurring once measured is given by the square of the amplitude of its individual wave function (see Equation 2 note). Then, after being measured, the particle would assume one of these possible states and its wave function would collapse to represent this singular state so that the particle is described only by this state - if the state of the particle were once again measured under equal conditions, the only possible state in which the particle could be found would be the one it assumes after the first measurement. For instance, assume that we know a particle is spinning, we just don't know in which direction, or in other words, the direction of its spin axis. For simplicity, let us assume that the probability that it is spinning in any direction is equal to any other. Now, if we were to set up our experiment to test the alignment of the axis, we would need to set up the detector along some arbitrary axis, say x. Then, regardless of the many possible directions the particle could have been spinning according to its probability, the particle will have a spin in the x direction. In other words, it appears that the state of the particle is dictated by the way in which is measured, and if it is not measured, it has an equal probability of being in any number of states. Now, if this particle were entangled with another and, say, their spins were diametrically opposed (particle 1 has spin +1/2 and particle 2 has spin -1/2 along some axis) then measuring the spin of one will mean that we know the spin of the other. If particle 1 were studied in the y-axis, then it will appear to be in the y-axis and its coupled particle will also be in the y-axis, but in the opposite direction.

Figure 3

Schemic Diagram of the 1922 Stern-Gerlach Experiments and the Projection Operator



Note. Reprinted from D. H. McIntyre (2012).

A simple depiction of the 1922 Stern-Gerlach experiments, which successfully demonstrated the quantization of the spatial orientation of angular momenta, is shown in Figure 3. If we take the unobserved, unmolested incident wave function $|\psi\rangle$, a sum of the possible spin states, and pass it through a polarizing filter, the functional representation of a polarizing operator, the state of the wave function will collapse along the basis of the filter. In the diagram, the filter is labeled Z for it polarizes the incident wave in the z direction, restricting its spin to the z basis. Generally speaking, a basis is the component along which a vector exists in a field; for our means and purposes these can be the basic Cartesian coordinates x, y, and z; so, the magnitude and direction of a vector can be described in terms of its bases. The projected output states, rather than the initial amalgamation of spin states along x, y, and z axes, will only occur along components the filter axis z. Because an axis may have positive or negative orientations, the filtered, observed wave function is the collapsed positive $|+\rangle$ or negative $|-\rangle$ z spin state of $|\psi\rangle$. The probabilities that the measured states are either positive or negative are determined by normalizing the produced, collapsed wavefunction, as discussed in A Basic Lexicon. What these experiments and mathematical principles indicate is that the counterintuitive notion that the state of a natural phenomenon depends of the choice of the observer is true. Pre-Platonic and dogmatic realism paradigms are incorrect. Apparently, choice creates reality. The emerging image of non-empirical confirmation in the form of interpretation of mathematical formulism in physics as shown here suggests that it is reasonable to expect that non-empirical evidence is significant in these contexts.

Bounds of Reality and Manifestation

If we can prove that a logically valid argument about the behavior of phenomena in terms of being, manifestation, and the reality of space and time is feasible, then we can see that non-empirical evidence may present valuable architectures of nature that correspond to physically observed laws.

Insofar as one may be concerned, the breadth of the partition between our epistemic and ontic capacities shapes our cognitive infrastructure in the regard of realism. Here then it appears that, of the physical processes in our universe, whose elements are purely fundamental, the gap in our comprehension is irascible if some extent elemental properties do not simultaneously exist. The greater viability of quantum mechanics, at least in the Copenhagen interpretation, is supported by the allegory of the spacetime object, forged later in this section. Here, the ability of an object to manifest in space and time is adjudicated only by its ability to be observed. That which is not measurable, cannot exist. This premise is most readily reflected in the implications of the uncertainty principle - the expectation values of non-commuting position and momentum operators, $\hat{x}$ and $\hat{p}$, respectively, do not exist simultaneously.

$$\Delta x \Delta p \geq \frac{\hbar}{2} \tag{7}$$

$$[\hat{x}, \hat{p}] = \hat{x}\hat{p} - \hat{p}\hat{x} = i\hbar \neq 0 \tag{8}$$

Note. Δx (the "uncertainty" in x) is basic notation for "the standard deviation of the results of repeated measurements on identically prepared systems" (Griffiths & Schroeter, 2018, p. 142). x and p are the observed quantities that result from the action of their corresponding operators.

By accurately measuring the position of a particle, the value of its momentum is made instantaneously and highly uncertain. A particle which *cannot interact with another* is then unable to belong in a spacetime paradigm. This is not meant to imply that a particle that has gone unobserved or void of interaction cannot be assigned reality. Until this particle is measured, its manifestations in any frame of reference can only be statistically applied as a superposition of its possible states. Positions in the spacetime box are points in spacetime, not particles, and are simply a set of coordinates whose origin is position occupied by a given being or entity. This tells us, roughly speaking, that the observable properties of a particle may undergo indeterministic fluctuations that prevent them from possessing constant values.

These unpredictable fluctuations are generally termed *uncertainties*, and the total uncertainty of a system is given as the product of the uncertainties of its properties. What the Heisenberg uncertainty principle demonstrates is that the product of these two uncertainties has a minimum non-zero value $\hbar/2$ (Equation 7), so the degree of uncertainty of the position could not be measured with infinite precision without blowing up the uncertainty of the momentum.

So, while a particle may be said to have a starting and an ending point in space, there is no way to know the exact route of its journey. The inability to accurately determine the position and momentum of a particle is not due to the systematic error of measuring equipment nor to the incompetence of the experimenter nor to the disturbance foisted onto the system by the act of measurement. It is because by natural law, the particle does not possess precise values for these properties - “It’s not that we can’t know position and momentum, it’s that they don’t even exist at the same time” (Carroll, 2019, p. 69). In the macroscopic scale, these fluctuations are minute enough to go unnoticed, and we may justifiably resort to classical mechanics in order to avoid the complications of prescribing many, many orders of magnitude of quantum interactions. Position and momentum are not properties of a particle, they are simply things we can measure about it - they are manifestations of its being in space and time. Quantum mechanics is a statistical distribution of probabilities, an epistemological tenet, a description of the extent of our knowledge of a system, but not an objective, ontological, or deterministic description of what *is*.

Given these parameters, consider an infinitely large box where a particle rests at the center. This particle is single and indivisible. This box is parametrized as a coordinate system by time and space as the manifestation of reality, so we may say that anything that exists inside the box is real in the most basic sense. Though one may consider a perspective outside of this box, it is important to remember that to attain such a vantage point is not possible for it is by definition only within the box that things happen. For our means and purposes, we may allow ourselves to take this impossible perspective and look down at this box, as if it could sit comfortably in one’s palm. Doing so allows the box to be arbitrarily large or small while infinitely large to the particle. If we imagine the box as infinitely small, then the particle sitting in the middle becomes indistinguishable from its box, from its coordinate system. We may do so as our position beyond the boundaries of the box is arbitrary. Insofar as we are concerned, the particle may itself be understood to be its own coordinate system within which the laws of physics are experienced if their infinitesimal sizes are perceptively indistinguishable The purpose of the coordinate system is to present a vicinity within which other entities may influence the center particle, and allotted the characteristics that would appropriately reflect the features of the spacetime we occupy, like spacetime curvature, relativistic effects, and conservation and symmetry rules, this particle in a box may serve as a philosophically-conceived model of a physically real universe.

In the following paragraphs, we shall consider why the assertions made by the allegory of the box must be true. First, with respect to the reality of a particle within a coordinate volume: it must, at least to itself, be real. Being must exist somewhere. In Heideggerian (*Dasein*) and Platonic (*Forms*) reasoning, an entity as a self-contained, self-evident, idealized configuration of existence extends beyond its materialistic entity. Considering oneself, it is obvious that one exists and in the confines of some reality defined by rules and dimensions, whose study generally falls under the moniker *physics*. Something is happening; and if something, anything, is happening, something must be real, somehow somewhere somewhen. This, of course, is not a nascent idea; its anthropomorphic predecessor is known as Cartesian dualism, *Cogito, ergo sum* (1637). It is under these assertions that we conclude that if we can idealize an entity to a particle in a system by which it may act on its surroundings, so long as the surroundings are reasonably defined, it must be real.

With regard to the choice of spaciotemporal postulates for a real physical system, it is evident that any system described in absence of time or space could not be considered a complete, real model. Postulates of reality define the structures upon which reality is built and by which it may be considered real. This paper will focus more diligently on the implications of time as viable parameter for reality as many published papers in physics have already done the same with regards to space (Rubakov, 2001). In the aforementioned tenet of real space, entities therein must be capable of interacting with other entities. Because interaction cannot exist timelessly, *time must produce reality*; without reality, there can be no time. We understand time as the rate of change *of change*. As such, where there is no change, there is no time, no reality. Change must be an epithet of interaction and the old Newtonian wisdom seems so far unchallenged: where a state is undisturbed by external forces, it remains unchanged. An extant being cannot exist if it does not change—that is, if it does not or cannot interact with another being within its world-space. Thus, existence requires time, it requires change; a thing cannot exist in isolation. It is also true that a thing cannot experience self-induced change. If it could, the former argument would be invalid, for change would not require the existence of multiple entities to occur. Change then *could* occur in isolation. No such cases, other than the thermodynamic isolation of the universe as a systematic whole, have been physically conceived.

Spatial dimensions are plentiful, even theoretically excessive (Rubakov, 2001), time is generally maintained as an entity of a single facet. It may stretch, compress, and curve, but is nevertheless singly dimensional. The necessity for time as a progenitor to sequence, the evolution of events, suggests that reality is true on the basis that cause precedes effect, an aforementioned proposition of David Hume (1896). We must then surmise time to be a postulate of reality. The remaining postulate is spatial. Where time is a universal law, there is the ability to change and interact, but an absolutely isolated particle is absolutely still, invisible, and constant. It cannot exist. To exist inside these parameters is to be measurable—to be able to interact with other particles of a matter or energy—and evidently at least two fundamental units must inhabit the box. Thus, the conditions of the box require that space and time are real where there exists the capacity of interaction and the proclivity of manifestation of properties.

What exists, then? In the world-space of the allegory, meaning is symbolized by form. In this sense, the coordinate space symbolizes the archetypal realm of being for a physical object or phenomenon, and the Forms which inhabit it are the point sources from which a manifestation issues, and they are the only things that exist. The Forms are the projections of the idealized entities of substances onto the physical world. In this paper, these ideals are extensions of Plato's *Forms* mentioned in earlier sections. In reality, only material entities exist. Numbers, for example, do not constitute as forms and cannot be said to exist because they are meanings symbolized by a form of a certain multiplicity. Apart from Forms are Properties. Properties lead to consequence, which then allot them the ability to manifest in reality. Consequence is the tendency or ability of a thing to cause a change in another thing, and therefore, an interaction. Properties, though, do not exist in reality by themselves; they are characteristics, and so their location in space-time is that of their proprietor. They exist as discreet consequences, or tropes, of things within the coordinate system, but a *property* has its own singular unit. This conveys an interesting repercussion: things that do exist within our universe are not single units of anything but are bundles of properties. An electron has never, and could never, be pointed down to a single point in space, nor could any fundamental particle for that matter, but the exertion of its consequences allows us to understand its properties and capabilities, like its spin, charge, and mass, and energies. Spatial distance manifests itself in its own sort of instances, like gravitational attraction, electrostatic repulsion, and space-time curvature—different distances produce different reciprocated effects between objects.

Finally, let us better understand the implications of the box. Given a coordinate system of time and space, we may presume that any position within may allot existence to a particle, and we may say that only within these bounds do things happen. This coordinate system is the entity of *reality*. It then follows that in order to exist, an object must manifest in space and in time. However, the intuitive impulse to depict an object occupying that space as a physical particle is insidious. The truth is more nuanced. A thing exists as the sum of its causal consequences and manifestations within the coordinate system of reality. So, to exist is to *manifest* as a bundle of properties in spacetime that may cause a change of state, a consequence, upon another existing system.

Within the box, as in physical reality, the capacity for causal consequence to be measurable is a property of an object. As a *being-in-the-world*, in Heideggerian terms, the proclivity to manifest within a “world-space” is an attribute of a being. Otherwise, the being could not interact with another object and could never be asserted to exist within a real space. As a result, due to the limited range of the box, the coordinate volume of the particle, an entity may only manifest and thus be of any consequent capacity within the confines of its box. Thus, if each object belongs to its own set of coordinates, objects only interact once their coordinate systems overlap.

As a contrived philosophical system, the spacetime box is in good accordance to special relativity, which assumes no absolute spacetime coordinate system but accepts that each moving party belongs to its own coordinate set. As such, different frames of reference produce their own justified observations of reality, while disagreeing with the other frames.

I can present a simple depiction of this case: consider two people in the emptiness of space moving at a constant speed toward each other (meaning neither person is accelerating). With no external cues of relative motion, the lack of acceleration will beckon each person to believe that the other person is moving toward them, and that they themselves are not moving at all. We can’t really *feel* velocity; we feel acceleration. In a car ride home down one long, straight road, one will perceive motion only because the road is bumpy, or because one change lanes, or because the speed of the vehicle changes at a stop signs and traffic lights, or maybe because one sees other vehicles moving past. With eyes closed, moving along a perfectly flat road, no change of motion right or left, and no change of speed, it would be impossible to tell if one is moving at all. It turns out that each person in our example would be correct in asserting that it is not he or she who moves, but it is the other person that moves toward them, and that they themselves are perfectly still.

In the extent of the spacetime box, entangled particles share the same, but inverted coordinate space. The inversion allows for the conservation laws (energy, momentum, and angular momentum) of physical phenomena to hold due as a result of physical symmetries. They do not interact any more than a particle may interact with itself, a prohibited attribution of a fundamental particle. The probabilistic properties of quantum theory apply for the ambiguity of states, for the measurement (and observation, implying knowledge) of the wave function of a particle sharing the space of another simultaneously collapses both wave functions—beckoning the two to be justifiably describable by a single, composite wave function.

In these respects it is shown that an allegorical argument is capable of developing a universe within which conjectural phenomena coincide with physically recognized events. As long as these conjectures are critically examined, extrapolations taken from these systems can give rise to fair, significant results on non-empirical grounds. The results they produce are plausible inclusions in scientific analyses in the absence of experiment, though insufficient as complete descriptions of reality.

Objections

The following arguments present varying forms of disagreement with the arguments thus far presented. As such, some may not necessarily contend with the validity of non-empirical confirmation as a whole, but rather with the rationalizations this paper has put forward in order to qualify that notion.

Logical positivists push for the idea that a scientific statement is meant for the truth in philosophy to be confirmable, or unconfirmable, by measurement in such a way to demarcate whatsoever one may wish. As such, any qualifying conception of reality is justifiable under self-evident pretenses. Anything may be taken as a measurement of any other thing depending on the perspective taken by the observer. Then if an event is said to be caused by some action, every case in which that event occurs is attributed to the execution of the action. This conviction would see to it that non-empirical evidence, along with any other kind of rationalized evidence, becomes a circular, inert thought process whose viability would stand subject by its own assumptions. In the purview Logical Positivism, non-empirical remarks cannot be judged with respect to real events. A system of scientific validation like this one is not ultimately helpful in figuring out what is true. If the best way to explain some phenomena requires the existence of an essence whose being itself requires a great number of assumptions, it must be discarded. This is known as Occam's Razor, a tool used to discard explanations to complicated in favor of simpler, more plausible ones. By Occam's Razor, the possibility which requires the fewest assumptions is embraced as the best one. Then, the best definition of reality and the best description of behavior are those that require the fewest leaps and may be most readily proven by observation as an effort to minimize assumption. Under hierarchical system arranged on merit, the non-empirical, rationalized, critically scrutinized arguments which better serve to operate by the adequate physical conditions of natural science are the ones that should be maintained for consideration; and the rest discarded.

In the early stages of writing this paper, a common argument I encountered goes as follows: what makes us think that the explanations made by some humanoid primates stuck on a spec of dirt somewhere in the universe represent an accurate description of reality? One response, while far from exhausting all possible responses to the inquiry, is that it matters not what the *truth* is, only that no individual or perspective can seem to grasp the complete structure of nature. We are left to our own confabulations when we cannot close the gap between Form and the metaphysical boundary. Thus, there is no real condition whose nature may be reconciled by one's observations alone, as even if our efforts to realize the nature of some event coincide with its true being, they would be purely coincidental. One may think that any given sensory stimulus is real because one can feel, hear, or see them. These beliefs, paraphrasing Scott M. James (2011), a moral psychologist, are moreover connected to a *counterfactual*—"had we not been experiencing these things, we would not have believed they existed" (p. 171). If the stimuli did not manifest its properties toward an observer, the observer would not perceive that they did. Further, one may go so far as to claim that these events have causal relationships with experiences: "if we did not stand in these causal relations to our environment, we wouldn't be having these experiences" (James, 2011, p. 172). Thus, if it is the case that one believes to experience some external matter, one ought to require more than just the belief of perception to justify the reality of the existence of that external matter. The human observer can believe that it perceives an event, the cry of a bird, the color of budding flowers, but this belief requires the existence of neither the cry nor the bird not the flower; just that the mind believes that they do. In the end, we are the prisoners of our own belief system, which is independent and removed from the true occurrences of our world—the absolute truth.

Further, what makes a measurement a reliable reflection of the state of a system? Empirical data taken over a number of trials and state-specific conditions is a useful method in determining the likelihood of an event or characteristic. In this way, by conducting an experiment and creating a change in one system in order to observe the change in another, we may determine the form of interaction that pertains to a property of the latter system. Making this assertion over multiple trials then infers a high probability that the system does indeed react in this manner and manifest its properties to multiple observers under multiple conditions over a span of time approximately equally.

Regarding the viability of an abstract rationalization, some programs born of physical and mathematical parenthood are metaphysical. They are irrefutable; they cannot be tested. They are based on statistical interpretations of physical systems and if unchecked, the misguided among them could gain the potential to supplant the logical ones. And they attempt to illustrate the physical world—a perspective no longer bound and describable by the steady intuitions and experiences of its mindful inhabitants—one with careens, valleys, and peaks; one whose rules and behaviors are riddled by indeterminism and formulistic interpretations. Then, how could metaphysics be of any use? Is it anything more than a philosophical formulation, a tentative hypothesis whose claim of the form of the physical world is meant only to be considered? Popper argues, "as long as metaphysical theory can be rationally criticized, I should be inclined to take seriously its implicit claim to be considered, tentatively, as true" (Popper, 2005, p. 199). And so long as these metaphysical dogmata may be superimposed upon a hierarchy of reason—a hierarchy of intuitive forms whose physical and mathematical progenitors fit our world may be distinguished as better or worse in terms of the validity of their presumptive conditions—we should be inclined to evaluate them. Then the most useful among them may be rationally appraised, pursued to compare against the most valid theories which it is meant to supersede, upheld if fruitful, and the rest can simply be abrogated.

This seems reasonable on the surface. After all, why should anyone expect to validate an untested theory on equal grounds to intuitive, proven experiment? Disposing of the requirement for valid evidence when searching for useful theories would result in no structure upon which to build any reasonable argument. If there were no hierarchy of reason in physical or metaphysical claims of the world, it would take an unsustainable amount of time and resources to determine the best course of thought or action for the most trivial matter. These conceptual paradigms by which we may yet transcend the infelicitous pace of technology must be absolutely reasonable. And quite frequently they arise from blank slates, whereupon carefully lain pieces of logic stack upon one another, aiming to reach high and well enough to explain the nature of the world.

More and more often, we see that these philosophies come *from* the mathematics and physics that we entrust to serve as ultimate objective measurement tools. We see this in wave functions, in general relativity, in string theory, and the technology that implements them. These perturbations to the peaceful physics we could bask in centuries ago have grown in size over time but exploded after the development of the theory of relativity. How would we compensate for the diaphanous philosophy of space and time of objects in relative motion if there is no single language that could describe the reality of the universe? Werner Heisenberg (2000) put it:

> "Should one say the structure of space and time was really different from what it had been assumed to be or should one only say that the experimental results could be connected mathematically in a way corresponding to this new structure, while space and

> time, being the universal and necessary mode in which things appear to us, remain what they had always been?” (p. 119).

Physics as well as philosophy operates under its fair share of assumptions and approximations. When describing abstract concepts like electric fields, physicists tend to assume the perspective of a bystander infinitely distant from the event. When analyzing a number of quantum mechanical phenomena, ones take the bold purview of classical phenomena, going so far as to allotting “spin” to zero-dimensional particles, picturing them as spinning balls, except that they are not balls, and they are not, per se, spinning. These approximations take hold principally because the human mind does not possess a dynamic enough language to accurately describe physical phenomena.

Conclusion

In this work we have examined whether cases which substantiate the utility of non-empirical evidence in quantum mechanics contribute in some way to an operational description of physical reality. It is shown that ontological argument, epistemic restrictions, and physical observations and rationalizations are genetically related. Their bifurcation some 2,500 years ago is shown to be the result of the proliferation of the Platonic and following Aristotelian notion of separation of experience and meta-experience. This means that despite being currently founded on different forms of evidence, the fields of physics and philosophy follow the same form of criticism in order to reach a more profound and objective truth, which neither field claims to be capable to grasp in its absolute form.

There are many senses in which one can speak of the physical reality of nature, and it is of great difficulty to determine which sense is the best one to do so. This paper builds the abstraction of a spacetime volume in order to present a frame of reference within which the interactions between systems may give rise to reality by the propensity of their general manifestation. In an attempt to refute the completeness of quantum theory, the paradox of the EPR paper ended up embossing its probabilistic interpretations with entanglement, a physically sound phenomenon (Bell, 1964). Through the elements of reality, it is shown that observables and probability densities present the most characteristic features of a real system, challenging the deterministic view at this level.

This paper refutes the notion that philosophical arguments, that is, non-empirical evidence, should not be taken seriously in a scientific environment. So long as a metaphysical theory is rationally discussed and thoroughly criticized, it should be taken seriously as a valid proposition. Not unlike a nominal scientific theory, the philosophical schemes must not go unabated. All arguments that function as a coherent set in conjunction may form promising arguments where the limitation of technology does not provide the privilege of testing mathematical theory.

Where once we could have relied of prompt production of laboratories and experimental equipment to test theory, today's circumstances are different. During and prior to most of the twentieth century, fundamental physics was perceived as a field in which most theory could be tested within a reasonable time frame (Dawid, 2019, p. 99). The advent and development of quantum mechanics in the last century has since brought forth illustrious complications to the long-departed comfort of relatively ready modes of experiment. In cases of new theories like string theory, the standard of predictive success by which the validity of previous theories, like high-energy theory or general relativity, were measured proves invalid for theories like these relatively complex and insufficiently understood. From alchemy, the proto-scientist's quest to the philosopher's stone, a material that would ostensibly free mankind from its pathologies, came chemistry and the modern sciences (Jung, 1980); and from the luminiferous aether, the theorized medium through which light travels, relativity (O'Dowd & Wells, 2020). It is obvious that modern science did not form spontaneously but evolved from rationalized speculation and hypothesis. Thus, if non-empirical evidence has produced established sciences it is at least reasonable to conclude that non-empirical confirmation has the capacity to deliver valuable scientific bases and that from it a number of them have arisen.

The foregoing arguments have so far discussed the philosophical implications of modern physics to show that the two are inextricably linked. In considering the great expansion of modern physics, it would be impossible to separate it from the natural intricacies of un-testable evidence. If metaphysical claims about the physical world can be rationally ostracized, their predictions, assumptions, and implications may unify an enlightening image of true natural phenomena. Disregarding them all would be at the peril of fruitful development as the technology to test them progresses. It is here, perhaps, that we may find that natural sciences, as they were born and as they have grown, do not so greatly differ from rational philosophy. This paper does not claim that non-empirical confirmation is sufficient to conclusively prove any one given natural phenomenon. But in the respects where relevant non-empirical evidence is capable of providing significant contributions in the absence of robust technological experimentation, a meritocratically-structured system in the natural sciences ought to consider it seriously in direct proportion to its competence.

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